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INDIA-RUBBER.

The Chemistry of India-rubber. By Carl Otto Weber, Ph.D. Pp. x + 314. (London: Chas. Griffin and Co., Ltd.). Price 16*s.* net.

DURING the last few years the development of the india-rubber industry to meet cycling, motoring, and electrical requirements has produced quite a crop of descriptive handbooks, among which those of Brannt, Henriques, Seeligmann, Clouth and Warburg are the works which come most readily to mind. As a rule, however, these treatises have dealt more particularly with the manufacturing and commercial aspects of india-rubber production, and the scientific side of the subject occupies in them a relatively subordinate place as one matter among many. In the volume before us, the author has applied himself specifically to the chemistry of india-rubber, and incidentally to that of its various substitutes. Dealing, as he does, with only the scientific portion of the subject, he has naturally treated this branch far more exhaustively than previous writers have done. But pure science is even here tempered to the technologist, for almost throughout the book the point of view is that of the working—one had almost said of the works—chemist. Theoretical exposition and practical application jostle one another in every chapter; what to do, and the reason for doing it, rub shoulders together from cover to cover. It may be said at once that the result is an eminently useful contribution to the literature of india-rubber and its congeners.

The book contains nine chapters and an appendix. In the first chapter, which forms more than a third of the work and gives its title to the whole, Dr. Weber deals with the constituents of india-rubber, discusses their physical and chemical properties, and propounds in outline a theory of vulcanisation. The carbohydrates present in crude "unwashed" rubber are first referred to, and then follows a useful little table showing the proportions of resinous extract obtained from the various commercial brands of technically-pure rubber by treatment with acetone. It may be explained that the importance of these "resins" lies in the fact that they allow the chemist to discriminate between a high-quality rubber, such as Pará, and an inferior product like some of the African kinds.

Passing on to india-rubber proper, the author summarises the evidence which goes to prove that the pure rubber substance is a hydrocarbon of the terpene type. Oxygen, it is true, is always present in commercial specimens, but it is partly accounted for by atmospheric oxidation and partly by the presence of an "insoluble" compound having the empirical formula of a hydrated terpene. This last, the author suggests, may be an intermediate product between india-rubber itself and the carbohydrates from which, perhaps, the various terpenes are manufactured in the cells of the rubber plant.

Organic chemists have apparently found the chemistry of india-rubber somewhat unattractive. Gladstone and Hibbert's well-known paper, published some fifteen years ago, still remains the chief contribution to the subject. No doubt this is largely due to the intractable nature of the compound; for india-rubber, from this point of view, certainly possesses the defects of its qualities. It has few points of attack; there are none of the carbonyl-, carboxyl-, amido-, imido-, hydroxy- or methoxy-groups in which the organic manipulator delights; it cannot be readily dissolved; and *a fortiori*, being a colloid, it cannot be crystallised. Nevertheless, it has one vulnerable spot, and the Achilles' heel in this case is found in the existence of the "ethylene bonds" pointed out by Gladstone and Hibbert in the paper already referred to. The advances that have been made in the chemistry of this refractory substance have followed almost exclusively from the study of india-rubber as an "unsaturated" compound. From a consideration of its addition-products, our author concludes that the india-rubber molecule has probably an open-chain structure, and that its molecular weight corresponds, in all likelihood, to a high multiple of the empirical formula $C_{10}H_{16}$, with $C_{50}H_{80}$ or $C_{60}H_{96}$ as a possible minimum.

Much stress is laid upon the colloidal properties of rubber as being the clue to a proper understanding of its behaviour during manufacture. Graham's classical researches on colloids we are all supposed to know, at least in substance; but Dr. Weber appears to think—perhaps justly—that most of us are content to take them as read, since he remarks that they are, if not forgotten, certainly realised by very few present-day workers. For our sins in this respect we are treated to a twenty-five page disquisition on the colloidal state, leading up, however, to an interesting study of the phenomena of vulcanisation.

In the author's view—the experimental evidence for which is set out at some length—the vulcanisation of india-rubber by means of sulphur consists essentially in the direct addition of sulphur to the india-rubber hydrocarbon (polyprene), with the formation of various polyprene sulphides ranging between the limits $C_{100}H_{160}S$ and $C_{100}H_{160}S_{20}$. The particular sulphide produced depends upon the degree of vulcanisation, which itself is a function of the temperature, time, and proportion of sulphur present. Combating the theory that the action of the sulphur is one of substitution instead of addition, the author rightly points out that if the former were the case the vulcanisation of a ton of rubber would mean the production of about 18,000 litres of hydrogen sulphide—a daily amount which would make the vulcanising rooms fairly reek with the gas. In reality, only insignificant traces are found there. The cold process of vulcanising by means of sulphur chloride is also discussed in detail; alternative methods are mentioned, and the whole section, which is embellished by half-a-dozen photo-micrographs, forms a highly interesting and suggestive little monograph upon the inter-relations of sulphur and rubber.

In the succeeding chapter the technical examination and valuation of india-rubber and gutta-percha are dealt with. But in this industry, as in so many others, our manufacturers cling hard to rule-of-thumb methods; stocks are bought on the strength of a cursory empirical examination; and we read that, in consequence, different lots, supposed to be of identical quality, "often show the most absurd variations" when properly appraised by analysis. The following quotation speaks for itself:—

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"Pig iron, caustic soda, wood pulp, and scores of similar articles, costing, comparatively speaking, a few shillings per ton, are bought and sold on the basis of strict analytical standards; but india-rubber, costing from 150*l.* to 500*l.* per ton, changes hands without either buyer or seller having more than a vague knowledge of its intrinsic value."

A full description is given of the various india-rubber substitutes now so frequently used, and which consist either of recovered rubber from cast-off articles or of the products obtained by the action of oxygen, sulphur or sulphur chloride upon such substances as linseed or colza oils. Inorganic compounding materials, vulcanising agents, solvents, colouring matters and textile fabrics each claim a chapter; and, as might be expected from a writer of Dr. Weber's experience and attainments, the treatment of all these subjects is eminently practical without in any degree lacking scientific precision.

Analysts and technical chemists who are called upon to examine india-rubber will be grateful for the chapter on the analysis of rubber articles, with which the volume proper closes. Information previously scattered in periodicals is here readily available, and the usefulness of the chapter is much enhanced by a section dealing with the interpretation of analytical results. Chemists should note that nitro-naphthalene is recommended as a "solvent" for india-rubber in preference to the nitro-benzene hitherto generally employed.

On the whole, the author's style is lucid and his English readable. Occasionally one meets with a tortuous sentence or a quaint prepositional usage, and the book generally, perhaps, lacks lightness of touch. Here and there, also, a word occurs which does not exactly convey the meaning intended, and rather reminds the present writer of the youthful essayist who, describing a storm at sea, remarked that a boy was drowned before his parents' eyes, and that "it was all the more awful because the father and mother were just on their honeymoon." Such blemishes, however, are small matters in a work of this kind. The book was wanted, and is a welcome acquisition. It is written by a man who knows his subject and who writes as if he loved it. The author is to be congratulated upon a very useful contribution to a somewhat obscure and difficult branch of technical science.

C. SIMMONDS.

A BRITISH BOOK OF CONSTANTS.

Physico-Chemical Tables. Vol. I. *Chemical Engineering and Physical Chemistry.* By John Castell-Evans F.C.S. Pp. xxxii + 548. (London: Chas. Griffin and Co., Ltd.) Price 24*s.* net.

THIS volume is the first half of an elaborate work intended to be a compendium of tables and data covering the whole domain of physical chemistry, for use both in the laboratory and the works. The scheme is an ambitious one, and the labour of compiling the present 548 pages of closely printed matter must have been no light task. The book which Mr. Castell-Evans's work most closely resembles is undoubtedly Landolt and Börnstein's well-known treatise, which is about the only one with which the writer is acquainted covering the same field. The chief difference between the two books lies in the fact that Mr. Evans has included about sixty pages of arithmetical and algebraical data, which should prove quite useful.

The book is, on the whole, well arranged and exceedingly comprehensive, and some of the original tables it contains are among the best. The reviewer feels, however, that one of its chief demerits lies in the over-elaboration of some matters and the very unnecessary rows of figures, which many of the tables give.

For instance, what possible significance can the last two or even three figures have, when from table 47 G we learn that a barometer column of 30 inches at 54° F. is equivalent to 29·940213 inches at 32° F.? or of what use is it to have the equivalent of a mile in metres given to fourteen significant figures when 10^{-8} metre is about the limit attainable in the comparison of primary standards of length of the highest class?

Regarding the material of the work as a whole, a careful perusal gives a general impression that the author collected his materials and retired into his study to write his book six or eight years ago, and when the book came to be published overlooked the fact that our knowledge of some of the most important questions dealt with has advanced very materially during this period. For instance, we look in vain, under the specific heat of water or mechanical equivalent of heat, for mention of the work of Griffiths, of Schuster and Gannon, of Callendar and Barnes, or of Reynolds and Moorby, whose different researches, all published during the past few years, have practically settled this question. While dealing with this point, we notice that there occurs here in the familiar form the good old text-book tradition that Regnault *determined* the specific heat of water between ordinary temperatures and 100° C. In justice to Mr. Evans, however, we should mention that in his book several other similar errors, which we had come to recognise as almost always with us, are conspicuous by their absence, and the book bears strong evidence that in a great many cases the original authorities have been consulted.

We have verified many of the numbers, and have not detected many serious errors properly so called. In some cases, however, this may be due to the decided superabundance of data in many of the tables (as, for example, that of melting points on pp. 380, *et seq*). We find there for the melting point of gold,

1140°, 1200°, 1037°, 1092°, 1240°, 1250°, 1380°, 1100°, 1035°, 1045; most probable value 1050°;

and for silver,

999°, 1024°, 1000°, 1032°, 916°, 1023°, 1040°, 954°, 968°; most probable value 968°;

whereas modern authorities are agreed that 1062 ± 2° is a close approximation for the melting point of gold, that of silver in a reducing atmosphere being very sensibly 100° lower.

The most commendable part of the book is the section dealing with vapour pressures, critical volumes, &c., the results of the voluminous researches of Ramsay and Young and other modern workers being here, with both formulæ and tables, given in full.

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